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營運風險與現金持有量
Operational risk and Cash holdings

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摘要

本研究探討了營運風險與公司現金持有之間的關係，以了解公司如何根據感知的風險調整其 現金持有量。我們的基準結果一致支持假設 H1A，該假設認為營運風險與現金持有量之間存 在正相關性。這樣的結果代表公司通常在面臨較高營運風險時，會選擇增加其現金持有量， 以因應未來的不確定性。同時，公司可以透過持有現金來維持流動性，以防止未來不確定性 所引起的財務困難或緊急情況，或避免由於流動性不足而導致的低效投資。這些結論在使用 不同的現金持有量指標和工具變量分析進行測試時仍然穩健。此外，我們的擴展分析顯示， 在以下情況下，公司顯著增加其現金持有量：（a）較大的董事會規模，（b）較高頻率的財務重編次數，（c）較低的組織複雜性，以及（d）較高的槓桿率。最後，我們的研究還表明， 現金持有策略不僅受到營運風險的影響，還顯著受到槓桿和整體資本結構的影響。這些因素 共同決定了公司如何在風險管理需求和財務負擔之間取得平衡。

關鍵詞：營運風險；現金持有量；資本結構；文本分析；收益電話會議

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Abstract

This study examines the relationship between operational risk and corporate cash holdings to understand how companies adjust their cash reserves in reaction to perceived risks. Our baseline results consistently support Hypothesis H1A, which posits a positive correlation between operational risk and cash holdings. This implies that companies typically choose to increase their cash holdings when faced with higher operational risks as a precaution against future uncertainties. Firms can maintain their liquidity by holding cash to protect against future risks or uncertainties that could cause financial difficulties or emergencies, or to avoid inefficient investments due to a lack of liquidity. These conclusions remain solid when tested with various alternative metrics of cash reserves and through the use of instrumental variable analysis. Furthermore, our extended analysis reveals that companies significantly increase their cash holdings under the following circumstances: (a) larger board sizes, (b) higher frequency of financial restatements, (c) lower organizational complexity, and (d) higher leverage. Lastly, our research also demonstrates that the decisions regarding cash holding strategies are influenced not only by operational risks but also significantly by their leverage and overall capital structure. These factors collectively determine how companies balance risk management needs with financial burdens.

Keywords: Operational Risk; Cash Holdings; Capital Structure; Textual Analysis; Earning Conference Call

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1 Introduction

1. 1 The Importance of Risk Management

According to The Global Risks Report ([Anon], 2023), enterprises are continuously facing a multitude of risks. These include climate environmental risks, debt crises, and the risks associated with non-food supply chain failures, among others. These risks are exacerbated by global pandemics and economic policies, further complicating their impact on businesses. The 2023 Global Risks Report also indicates that business patterns of low growth and low investment are likely to emerge. We have reviewed past research on various business risks to identify which risks are currently most significant and worthy of further study.

Initially, Kauppi et al. (2016) focused on operational risk management due to the increasing complexity of supply chains and the intensification of operational risks. Their findings demonstrate that companies employing risk management practices and external integration strategies achieved optimal operational outcomes. Similarly, Munir et al. (2020) also conducted empirical research based on the premise that modern businesses operate in a rapidly changing and complex environment, increasingly relying on intricate networks of supply chain partners to deliver goods and services on time under continuous cost and quality pressures. Their study verified the relationship between supply chain risk management and the integration of suppliers and customers, and illustrated the impact of operational risk management on operational performance. Araz et al. (2020) used real data from retail, fresh produce, and aviation to analyze operational risks related to inventory management, the number of suppliers, financing models, and the cost of production, monitoring the benefits of operational risk management. They also found that

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effective identification and management of risks are crucial for businesses, enabling them to choose the most appropriate financing models, assess uncertainties, or external disturbances that would help achieve optimal cost-effective operational decisions. More specifically, the complexity of operational systems makes them difficult for non-experts to understand, thus operational risk management has become a core focus in both operational management theory and practice, requiring managers to have a comprehensive understanding of changes in the external environment (Lewis, 2003). Lastly, a survey conducted by Fuller et al. (2022) of 875 American C-suite executives and board members found that operational risk is the most important among all categories of risks. Hence, we determined that operational risk management is the most crucial and deserving of attention today.

We also observed the real operational situations of companies from corporate earnings call transcripts. For example, during the Q2 2021 Earnings Call, James Hardie Industries plc, a global building materials company and the largest global manufacturer of fiber cement products, disclosed that they were facing challenges with manpower and shipyards due to the COVID-19 outbreak, which curtailed LNG demand growth in 2020. Additionally, lockdown measures in Singapore led to the docking of 3 ships for over 100 days. Such operational risks resulted in partial fleet stoppages and reduced revenue. Consequently, the company mentioned that they expected to repay approximately $19 million of debt in the remaining time of the year, totaling $107 million, reducing the debt balance. Since repaying debt can reduce interest expenses and improve cash flow balance, it makes the company more resilient to uncertain operating environmAnother example is from the Q3 2020 Earnings Call of Prospect Capital Corporation, where they mentioned facing multiple external risks causing cash flow volatility, negatively impacting the

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financial condition of the business. For instance, they faced issues in the CLO market where the repricing speed of assets and liabilities deferred, thus the interest rate discrepancy between assets and liabilities affected the company's profits and liquidity. Additionally, the risks of collateral and tranche downgrades could lead to asset depreciation. Therefore, holding more cash to enhance liquidity could be one of the important measures for companies to cope with market fluctuations and ensure sufficient funds to address emergencies or financial pressures.

1.2 A New Measure of Operational risk

Upon recognizing the importance of identifying operational risk management in influencing corporate operations and financial decisions, we aim to develop a novel method for recognizing operational risks. Moreover, we explore how corporate operational risks correlate with cash holdings, thus addressing the research gaps between operational risks and cash holdings. Tazelaar & Snijders (2013) advocate for a more scientific approach over reliance on expertise and intuitive judgment in operational and supply chain management for risk assessment. Several methods have historically been used to identify operational risks. For instance, Jallow et al. (2007) adapted the COSO (Enterprise Risk Management Integrated Framework) to identify risk factors that could impact business process objectives. Specifically, they conducted a risk assessment for each business process activity, quantified risk factors within each activity, and simulated associated uncertainties to identify risk factors affecting business process objectives. Furthermore, Cebi et al. (2022) proposed using the concept of fuzzy set theory, employing optimistic and pessimistic functions that align closer with human thought and perception to assess risks, arguing that traditional risk assessment methods rely too heavily on expert knowledge and subjective assessments. Gillet et al. (2010) evaluated operational risks by

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analyzing operational loss events announced by financial institutions and corresponding stock price reactions. Samad-Khan (2008) introduced a new operational risk framework to assess and capture risks, utilizing historical loss data transformed into loss frequency and severity formats over specified periods to measure expected and unexpected losses for risk categories.

In summary, much of the past literature and empirical studies typically capture operational risks by analyzing incidents of losses that have already occurred or historical data. Moreover, operational risk management is usually conducted by internal professionals within corporations, and external individuals cannot observe company operational risks immediately and directly. For example, a company's internal risk management team often collects relevant data, information, and opinions for risk assessment and incident analysis; the internal audit department independently evaluates and inspects the organization's operational activities, risk management, and internal controls; the research department gathers and compares operational efficiencies, risk management practices, and performances of other organizations within the industry to identify strengths and weaknesses and to develop improvement strategies. Therefore, to proactively identify and measure operational risks before loss events occur and to effectively capture these risks, we attempt to analyze corporate earnings call transcripts—a more in-depth and immediate source of internal information—as well as corporate disclosures about operational status. This approach aims to identify management's attitude towards and the severity of current operational risks, subsequently testing how companies formulate financial and operational decisions.

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1.3 Contributions

This study focuses on the operational risks faced by corporations and aims to propose a new method for measuring operational risks. It also explores how these risks correlate with cash holdings, thereby addressing the research gaps between operational risks and cash holdings.

In recent decades, much attention in books and papers has been devoted to operational risks within financial services, focusing mainly on concepts and statistical aspects of operational risk management, rather than the actual connection between operational risks and financial decision-making. Therefore, one of our study's goals is to fill the research gaps in operational risks in industries beyond finance, bringing more attention to operational risks within various industry sectors. Moreover, the composition of risks today is more complex, as no single indicator can measure complex risks, as noted by Amess et al. (2015). The long-term trend of increasing corporate cash holdings over decades may be attributed to technological advancements and capital market reforms. For instance, automation and the development of information technology have improved inventory management efficiency, thereby reducing firms' reliance on cash; or financial innovations may have altered firms' financing structures and their dependency on cash (Amess et al., 2015). Our research includes different operational risk factors faced by various industries over time, thereby capturing a broader range of annual and scale risk factors to some extent.

Another contribution is that we will report how operational risks affect a company's cash holdings, a connection that seems to be underexplored to date. The importance of cash holdings lies in that it is a way for businesses to maintain flexibility, easily understood

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through examples from previous earnings calls. An increase in cash holdings is associated with an increase in extensively studied individual risks (Bates et al., 2009). When firms have ample internal liquidity, they perceive less value in obtaining liquidity from credit lines, as ample internal liquidity enables them to more easily meet potential funding needs, thus reducing their dependence on external credit (Campello et al., 2011). Therefore, cash holdings significantly impact corporate value and market valuations, with the market assigning higher valuations to companies that maintain liquidity (Faulkender & Wang, 2006). Furthermore, based on past scholarly research, we find that the motives for firms holding cash can be explained from multiple financial perspectives; thus, we seek to empirically demonstrate which viewpoint best matches the behavior of contemporary firms holding cash, or if firms are actually influenced by a combination of these perspectives.

Past perspectives on the motives for corporate cash holdings can generally be classified into three categories:

First is the transaction cost motive and precautionary motive described by Keynes (1936). Firms, by holding cash and liquid assets, can reduce financing costs, thereby avoiding the transaction costs of selling significant assets to raise funds. Additionally, firms can maintain their liquidity to protect against future risks or uncertainties that could cause financial difficulties or emergencies, or to avoid inefficient investments due to a lack of liquidity. This viewpoint aligns with the study by Almeida et al. (2004), who showed that cash sensitivity to cash flow is positive for firms under financial constraints, thus firms increase their cash holdings as cash inflows increase.

Next, as mentioned in the paper by Opler et al. (1999), cash holdings may depend on the optimal capital structure, i.e., firms choose their capital structure by balancing the tax

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advantages of debt financing with the costs associated with debt (Bradley et al., 1984). If firms anticipate sufficient tax shields to offset the costs brought by debt, they might opt for a higher proportion of debt financing, thus deciding the optimal amount of cash holdings. The optimal amount of cash is determined through the amount of debt, and they decide the optimal net debt amount based on the best capital structure. Acharya et al. Acharya et al. (2007) also found that firms use different combinations of cash and debt to transfer resources, such as financially unconstrained firms systematically preferring to use surplus cash flows to reduce debt.

Lastly, firms might hoard more cash due to pursuing private benefits, known as the agency problem, as discussed in numerous literature. When cash is available, executives are likely to use it for personal benefits (Jensen, 1986 , Kim et al., 1998, Dittmar & Mahrt-Smith, 2007). For example, the study by Subramaniam et al. (2011) mentioned that diversified firms might face more severe agency problems, stemming from department managers competing for the company's overall resources. The more influential departments within the company receive more resources, which could lead to overinvestment and other inefficient costs. Therefore, for diversified companies, the marginal costs of holding cash and liquid assets are higher, creating these agency costs. Research by Liu & Mauer (2011) also shows that the part of a CEO's compensation structure that relates to the volatility of the company's stock is positively correlated with the amount of cash held by the company, indicating that when CEOs face greater risk-taking incentives, they are more likely to increase the company's liquidity, i.e., holding more cash.

Therefore, if the motives for firms holding cash align with Keynes's described transaction cost and precautionary motives, firms facing high operational risks will tend to hold more

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cash, and operational risks will be positively correlated with cash holdings. However, if the motives for holding cash align with the second viewpoint, where firms first decide the optimal capital structure and debt before deciding whether to increase or decrease cash holdings, then the relationship between operational risks and cash holdings could be either positively or negatively correlated. We want to explore how the transaction cost and precautionary motives and the optimal capital structure perspectives together form the relationship between operational risks and cash holdings. Studies have shown that a firm's target leverage is negatively correlated with specific risks, meaning that during high-risk periods, high-leverage firms because they set lower leverage targets (Rashid, 2014), gradually adjust their capital structure towards the target, and the average sample company eliminates its leverage and target leverage gap at a rate of more than 30% per year (Flannery & Rangan, 2006), thus holding less cash over the long term.

The remaining sections are organized as follows. Section two will introduce the definition of operational risk, the method of establishing indicators, hypotheses, and empirical strategies; section three will introduce the data and variables; section four will discuss the association between operational risk and cash holdings, including the results of the instrumental variable regression model and the robustness test results; section five will provide a summary.

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2 Theory and Empirical hypotheses

In this section, we will detail the hypotheses, research methodology, and steps of our study. First, it is crucial to clearly define what constitutes operational risk in order to establish a standard for measuring operational risk, and then to validate the operational risk indicators we develop. Our primary question is: what is the relationship between operational risk and cash holdings? Thus, we will formulate hypotheses and test them through our research methods and procedures. We will examine how the heterogeneity of corporate characteristics and operational conditions affects firms' cash holding decisions in the face of operational risks. Additionally, after exploring the main results, this study will delve into how operational risk affects other key corporate policies such as production decisions. Moreover, to ensure the rigor of our findings, we will utilize instrumental variable regression analysis, leveraging the exogenous shocks of operational risk to identify its impact on corporate financial decisions, thereby providing valid supplementation and empirical support for existing theories.

2.1 Definition of Operational Risk

We adopt the definition of operational risk from the BCBS Committee (2002), which characterizes it as the risk of loss resulting from inadequate or failed internal processes, people, and systems, or from external events. Studies using the same definition of operational risk are numerous (Chernobai et al., 2011, Wang & Hsu, 2013). They more specifically categorize types of operational risks, including "Internal fraud," "External fraud," "Employment Practices and Workplace Safety," "Clients, Products and Business Practices," "Damage to Physical Assets," "Business disruption and system failures," as

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well as "Execution, Delivery, and Process Management." Detailed definitions of each type of operational risk event are provided in Appendix A1.

2.2 Methodology for Constructing Operational Risk Indicators

We follow the methodology of Hassan et al. (2019), who construct a new measure to estimate risk by adapting tools from computational linguistics. This method has been widely applied in literature on various topics, with many scholars employing it to achieve significant research results, including studies on political risks at the corporate level (Gad et al., 2023), climate change risks (Sautner et al., 2023, Li et al., 2024), pandemic risks at the corporate level (Hassan et al., 2023), the impact of Brexit uncertainty (Hassan et al., 2024), and information security risks (Florackis et al., 2022). A key difference in our approach is the source of the dataset; we use the Compustat - Capital IQ transcript data, collecting approximately 405,000 earnings call records held by an average of 6,090 North American companies from 2008 to 2023. The actual distribution of the number of companies each year is detailed in Appendix A2. Typically, each company holds one earnings call per fiscal quarter, thus expecting four observations per company per year, with actual data averaging about 4.06 earnings calls per quarter.

Next, we process the text by splitting paragraphs into words, then removing common stop words and non-alphabetic characters, and finally matching our pre-established operational risk keywords to construct our operational risk indicator.

We do not subjectively create terms related to operational risk; since the primary concept we aim to capture is the level of operational risk faced by companies, we adopt a standard dictionary approach, capturing high-frequency vocabulary from operational risk management textbooks to build a dictionary of operational problem vocabulary.

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Examples of keywords are detailed in Appendix A3. For constructing risk vocabulary, we follow the approach of Hassan et al. (2019), using synonyms of risk from the Oxford Dictionary.

Below is the formula we use to construct operational risk, similar to how Hassan et al. (2019) measure political risk:

$$ORisk_{i,t} = \frac{\sum_{s}^{N_{i,t}} \left(1[s \in O] \times 1[|s-j|<10] \times \frac{f_{s,O}}{N_O} \right)}{N_{i,t}} \quad , (1)$$

where $N_{i,t}$ is the total number of words at time t for firm i; $1[\cdot]$ is an indicator function;s indicates the s-th word in the text; O is the dictionary of operational-related terms; j is the position of the closest synonym of risk or uncertainty. The numerator calculates the count of words related to operational topics that appear within 10 words of terms like risk or uncertainty. Additionally, we weight these words by their frequency of appearance in the text, reflecting the intensity of discussion related to operational topics.$f_{s,O}$ is the frequency of the word in the text, and N_O is the total number of words in the text. In essence, this formula checks for words related to operations that also appear with synonyms of risk in the text and scales them according to the total volume of words in the earnings calls.

After executing the above steps, we generate an operational risk score for each transcript. Next, we validate this indicator to demonstrate that it indeed captures risks related to operational themes.

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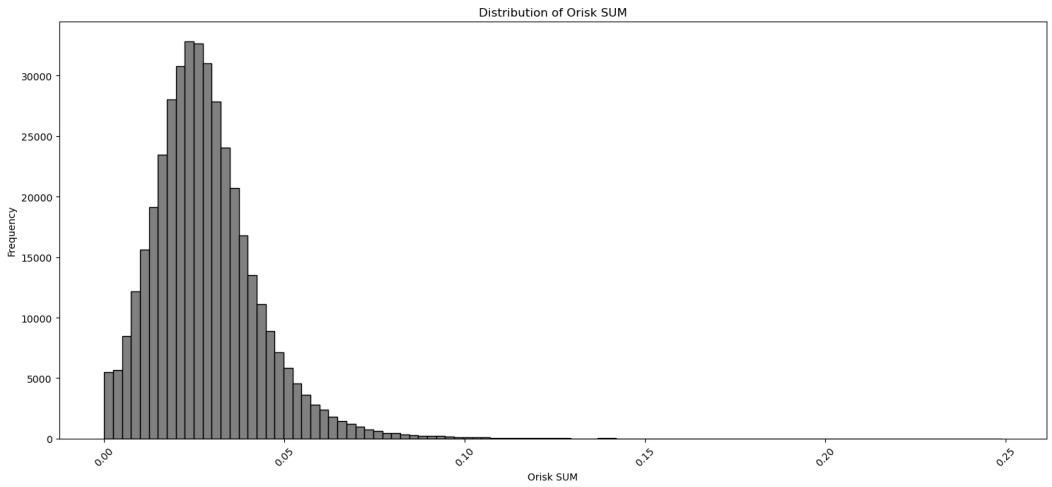
2.3 Measurement of Operational Risk

2.3.1 Distribution of Operational Risk

Our operational risk indicator exhibits a right-skewed distribution, with most of the dataset concentrated at lower operational risk(Orisk) values, while higher values occur less frequently. Furthermore, the histogram prominently displays the most common Orisk values, representing typical or common risk levels. The tail end of the distribution (right side) shows a few Orisk values that are significantly higher than the rest, which may indicate potential high-risk scenarios or outliers. The concentration of most data at lower values suggests that situations with relatively lower risks are more common in the entities or circumstances assessed.

Figure 1. The Distribution of Operational Risk.

Figure 1 illustrates the distribution of operational risk (Orisk SUM) across a sample of firms. The histogram, using 100 bins, reveals a right-skewed distribution with a mean of 0.0282 and a standard deviation of 0.0149, indicating substantial variation within the sample. The median operational risk of 0.0265, being lower than the mean, reinforces the right-skewed nature of the distribution. This suggests that most firms maintain operational risk below the mean, while a few exhibit significantly higher levels. The skewness and observed variation confirm the measure's robustness and its ability to capture a wide range of operational risk across firms, validating it for further analysis.



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2.3.2 Association between Operational Risk and Financial Metrics

According to Lord & Beranek (1999), research on operational risk began with Rubinstein (1973), and subsequent scholars have expanded on this topic, consistently concluding a negative correlation between operational risk and operational profits. Furthermore, Lord & Beranek (1999) empirically found that even indebted companies showed a negative correlation between operational profits and operational risks. Following their methodology, we matched our operational risk indicator with operational profits using the company unique key (gvkey) and also observed a negative correlation between the two. Conceptually, as these operational risk factors increase—such as risks associated with poor internal processes and control designs, improper execution, employee misconduct or non-compliance, or external events like natural disasters, political instability, or market fluctuations—companies face increased unexpected costs and losses, ultimately leading to a decrease in operational profit margins. Therefore, a negative relationship between company operational profits and operational risks is observed. This trend and phenomenon are clearly visible in the chart below.

Figure 2. The inverse relationship between operating profit and operational risk within the same companies.

Figure 2 plots the operational risk and operating profit over time. It shows the average operational risk over time between 2008 and 2022. The operational risk fluctuates over time and shows a negative correlation between operational profits and operational risks. For example, the operating profit has declined after 2008, 2018, and 2020, and the operational risk increases correspondingly. The 2008 financial crisis, categorized as Business Disruption and System Failures, caused global economic recession, reduced consumer spending, and tightened credit. The 2018 trade war between the U.S. and China, categorized as Clients, Products & Business Practices, increased market uncertainty and costs. The 2020 COVID-19 pandemic, also categorized as Business Disruption and System Failures, led to global lockdowns, supply chain disruptions, and a sharp drop in demand.

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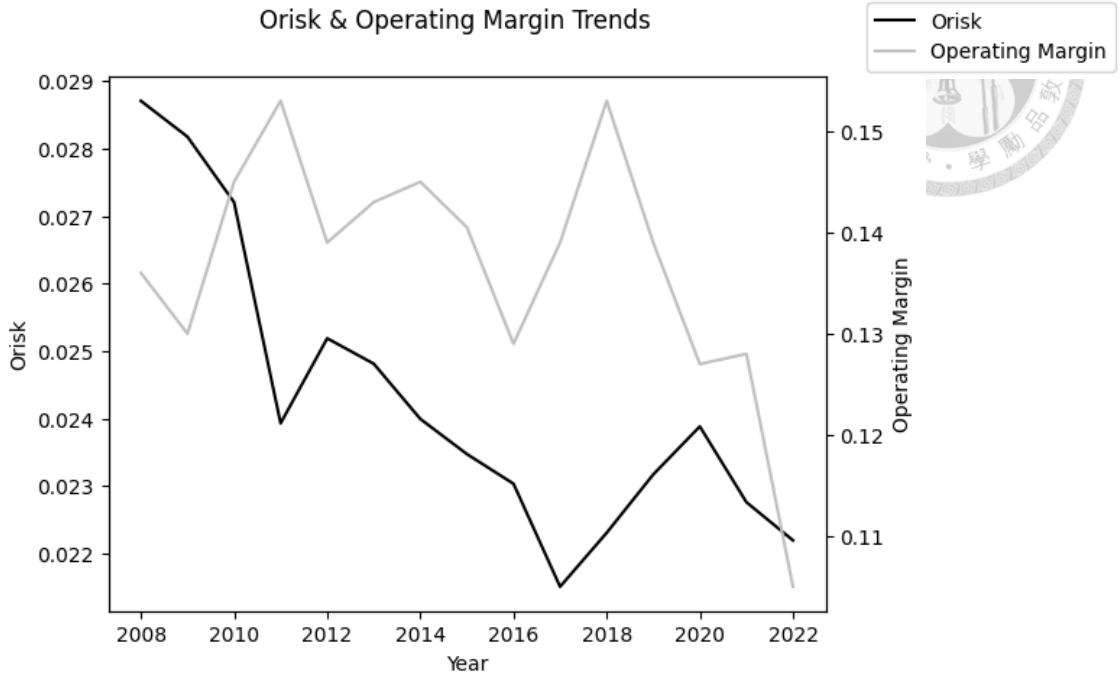

2.3.3 Validation of Operational Risk and themes

Lastly, we adopted another method to validate the indicator, following the steps of Hassan et al. (2019). We manually checked whether the operational risk indicator accurately identified discussions related to operational risk themes. We randomly sampled a number of texts identified with higher risks (operational risk above the median in the sample). Appendix A4 provides four examples of texts with high operational risks.

2.3.4 Trends and Factors Analysis of Operational Risk

The chart below illustrates the trend of average operational risk over time, highlighting peaks in 2008 and 2020 within our entire dataset. This observation seems intuitive, as operational risk arises from inefficiencies or failures in internal processes, people, systems, or external events. In the years 2008 and 2020, we infer that factors such as internal process failures, management, or system failures may have contributed to the increase in operational risks. For instance, the global financial crisis in 2008 and the COVID-19 pandemic in 2020 significantly impacted business operations. Many

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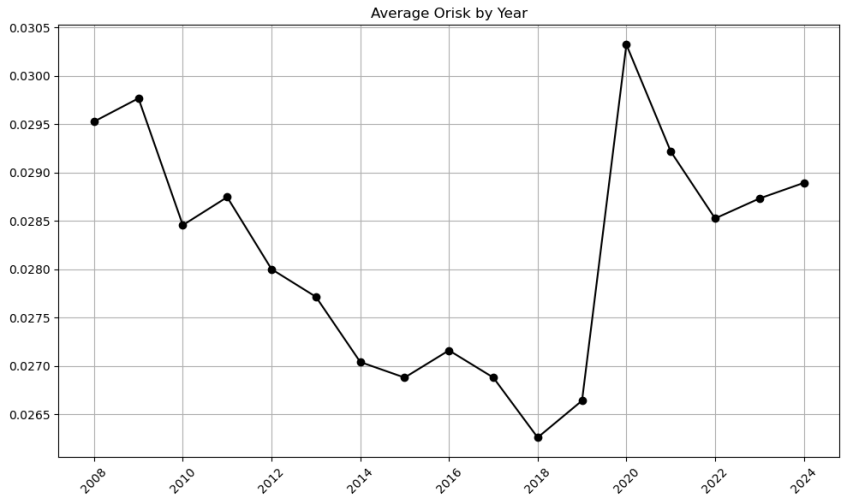
companies' internal processes likely failed to cope with these crises, leading to disruptions or chaos in critical processes like production, supply chains, and sales, thus increasing operational risks. Personnel issues could also exemplify the increase in operational risks, such as improper financial behaviors or poor risk management during the 2008 financial crisis, or the dramatic changes in employee work environments and methods during the 2020 pandemic, potentially affecting work efficiency, safety, and compliance, thereby increasing risks.

Figure 3. The trend of operational risk over time.

The chart displays the average operational risk trends, with significant spikes observed in 2008 and 2020. These peaks align with major global disruptions—the financial crisis of 2008 and the COVID-19 pandemic in 2020—that impacted businesses heavily. During these years, operational risks increased due to failures in internal processes, management shortcomings, and system breakdowns, which affected crucial business functions like production and supply chains. Additionally, these events led to personnel challenges and compromised risk management, further elevating operational risks.



We also conducted an analysis of the heterogeneity of operational risk-related conditions, finding significant inconsistencies in operational risks across different industry sectors,

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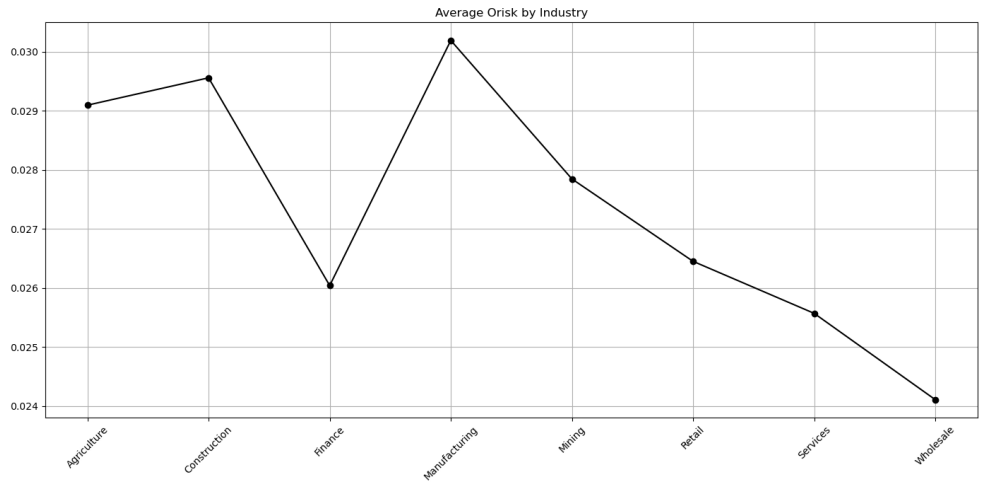
indicating that firms adopt different strategies in response to varying levels of market competition, macroeconomic environments, or regulatory policies.

Figure 4. Operational risk across industry sectors.

Figure 4 illustrates that the manufacturing and construction sectors exhibit notably higher operational risks compared to other industries. This elevated risk is largely attributed to their complex supply chains, stringent regulatory requirements, and labor-intensive operations. Additionally, substantial capital investments and the variable nature of project-based work further amplify the risk profile in these sectors.



2.4 Hypotheses and Anticipated Empirical Outcomes

This study focuses on the operational risks faced by firms, aiming to propose a new method for measuring operational risks and exploring how these risks correlate with cash holdings, thus addressing the research gaps between operational risks and cash holdings. We aim to test how operational risk correlates with the cash holding ratio, whether the relationship is positive, negative, or insignificant.

We reviewed several empirical outcomes, first observing what relationships exist between various risks and cash holdings. According to Harford et al. (2014), the literature indicates

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that refinancing risks have a positive effect on cash holdings. As refinancing risks increase, firms may hold more cash to mitigate risk. This phenomenon can be explained by firms wishing to have sufficient cash reserves to address unexpected financing needs when facing refinancing risks. Palazzo (2012) explored the relationship between cash holdings and the overall economic environment's risks, suggesting that firms facing higher economic environment risks are more likely to use costly external funds to finance their growth options and have a higher savings need to address potential future funding shortfalls, thus affecting corporate financing and investment decisions. This precautionary savings motive also implies a positive correlation between anticipated stock returns and cash holdings, especially evident for firms with fewer valuable growth opportunities. Xu et al. (2016) noted that the risks associated with political uncertainty significantly influence the decisions of firms regarding their cash reserves. During periods of political uncertainty, firms may adjust their cash holdings in response to different roles and policies of government officials. On one hand, firms might anticipate assistance from government officials, thus increasing cash holdings to address potential opportunities. On the other hand, firms may also fear punitive actions from officials, thus reducing cash holdings to minimize political extraction risks. Subramaniam et al. (2011) published findings on how the organizational structure of firms, whether diversified or focused, affects their cash holdings. The results indicated that diversified firms hold significantly less cash than focused firms. This difference in cash holding levels can be attributed to diversified firms having complementary growth opportunities across different business segments and the availability of internal capital markets. Lins et al. (2010) mentioned that non-operational cash is used as a general insurance policy against poor cash flow realizations; if a company anticipates needing more external funds in the future, or if they believe their stock is undervalued, they might not hold extra cash today because they can

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use credit lines to address future funding needs. Therefore, the non-operational cash stored by firms can be seen as a general insurance to address potential financial distress, with credit lines reserved as an option to support future business opportunities and growth plans.

Based on the literature review above, we can find that when firms face uncertainty in expected cash flows, they almost always choose to hold more cash to address potential future funding shortages. Therefore, we also formulate the following research hypotheses.

H1A: Positive Correlation Between Operational Risk and Cash Holdings

When firms face higher operational risks, the uncertainty of future cash flows increases. To ensure that they can address sudden funding needs and maintain sufficient liquidity, firms choose to hold more cash. This behavior reflects firms' precautionary measures against potential future financial pressures. By holding more cash, firms can more flexibly respond to unforeseen events, reducing the risk of financial crises caused by operational risks.

H1B: Negative Correlation Between Operational Risk and Cash Holdings

When firms face higher operational risks, holding more cash may not be sufficient to address the risks. Therefore, when the uncertainty of future cash flows increases, they do not hold more cash. For example, we find that Sanz (2023) showed both theoretically and empirically that firms with vulnerable supply networks tend to maintain less cash, higher leverage ratios, and more input inventories. Because in the event of a supply chain disruption, even with sufficient cash, firms struggle to quickly purchase or replace specialized input materials from the spot market. Thus, as supply network vulnerability intensifies, firms tend to reduce cash reserves and increase inventory, investing resources

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in more controllable and predictable management areas, such as inventory management, to minimize the impact of operational disruptions.

Furthermore, we will validate how transaction costs and precautionary motives, along with optimal capital structure perspectives, collectively shape the relationship between operational risks and cash holdings. According to Acharya et al. (2012), a firm's cash holdings are not merely a passive response to external environments, but rather an internal reaction based on potential scenarios of liquidity shortages. For example, if firms anticipate potential funding shortages in situations where external financing is restricted, they may be more inclined to retain more cash as emergency reserves. If the motives for holding cash are not solely due to transaction costs and precautionary needs but are also influenced by their capital structure, then firms will have an optimal debt amount and optimal net debt amount (total debt minus cash and equivalents). In such cases, the relationship between operational risks and cash holdings may be either positive or negative, depending on how firms balance risk management and capital costs. The concept of optimal net debt amount implies that firms try to reach a funding balance point that minimizes the cost of capital structure while maximizing financial flexibility.

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3 Data and Empirical Strategy

3.1 Data

To investigate our hypotheses concerning the determinants of cash holding decisions—specifically, the positive correlation between operational risk and cash holdings and the motives for holding cash in the face of operational risk, including transaction cost motives, precautionary motives, and the intersection with optimal capital structure—we constructed a sample for empirical testing. By merging Compustat annual fundamentals data with operational risk indicators, we created a sample of firms for empirical testing spanning from 2008 to 2023. The sample used to construct the operational risk indicators also begins in 2008. The categories of earnings call data we collected are divided into the following types based on the content of the meetings: Earnings Calls (73.5%), Company Conference Presentations (13.8%), Shareholder/Analyst Calls (4.4%), Special Calls (3.5%), M&A Calls (2.8%), and Analyst/Investor Day (2.1%), with detailed category descriptions provided in Appendix B1. Additionally, the categories of meeting participants are divided into five types:

- Executives: Top-level management personnel of the company, such as CEOs, CFOs, COOs, etc. They are responsible for presenting important information about the company's performance, strategic plans, financial data, etc., during the meeting.
- Shareholders: Investors who hold shares in the company. Their participation may aim to acquire information about the company's business performance and future prospects for investment decisions.

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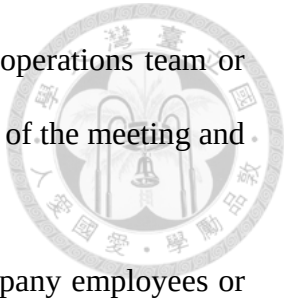

- Operators: May include members of the company's internal operations team or operators of the meeting itself, assisting in managing the flow of the meeting and providing technical support.
- Attendees: Apart from the roles mentioned above, other company employees or specially invited guests may participate in earnings calls to understand the company's business performance and future development.
- Analysts: Professional analysts from financial institutions or research organizations, analyzing the company's performance, financial data, etc., and providing corresponding investment advice.

After merging the above data, we excluded the following data: (a) financial firms, as indicated by Standard Industrial Classification (SIC) codes ranging from 6000 to 6999, and utilities, with SIC codes ranging from 4900 to 4949. Since their cash holdings are regulated, their business involves inventories of marketable securities included in cash, and they need to meet statutory capital requirements; and (b) firms with any missing financial data. Moreover, following Fama & French (1997), we categorized industries into 48 types. These industry definitions are to manage a number of different industries reasonably, with the proportion distribution of each industry available in Appendix B2. Therefore, our final sample consists of any firms listed on Compustat, totaling 48,684 firm-year observations. The sample size in analyses may be constrained by the availability of variables from other data sources, such as market prices.

3.2 Variables

3.2.1 Dependent Variables: Cash Holdings

Following the studies by Opler et al. (1999), Dittmar et al. (2003), and Harford et al. (2008), we use the logarithm of a firm's cash ratio as the dependent variable, which is

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calculated as the amount of cash and cash equivalents divided by total assets net of cash and cash equivalents. The logarithmic transformation helps to mitigate the impact of extreme values, making the model more robust and more compliant with statistical assumptions. Moreover, the transformation helps to reduce variability among different samples, making comparisons more consistent. In robustness checks, following Xu et al. (2016), we incorporate two alternative metrics for assessing cash reserves: (a) the cash ratio excluding cash equivalents, and (b) the variation in cash reserves.

3.2.2 Main Explanatory Variables

3.2.2.1 Operational risk

Following Hassan et al. (2019), we use text analysis of quarterly earnings call transcripts to establish a firm-level indicator of the degree of operational risk faced by publicly listed companies in the U.S. Most publicly listed companies in the U.S. hold regular earnings calls, where participants discuss the company's past and future performance or engage in Q&A. We quantify a company's operational risk at a specific time by calculating the proportion of words related to operational and risk themes mentioned in the calls. Specifically, we count the number of times these words are used together with synonyms for "risk" or "uncertainty" and divide by the total number of words in the text.

3.2.2.2 Moderating Variables

In addition to the basic regression, we include several moderating variables to account for potential factors that might change the relationship between operational risk and cash holdings, helping us to better understand the relationships between variables and ensuring that our results are not influenced by extraneous variables.

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First, we consider the size of the board (BSIZE). According to previous literature (Bhuiyan & Hooks, 2019), firms with a larger board size (BSIZE=1) may have more problematic directors, and firms with problematic directors tend to hold more cash.

Second, similar to the concept and methodology used by Chernobai et al. (2011), we use the firm's number of financial restatements (RESTATEMENT) to capture internal operational risks, as a higher number of restatements might indicate more financial reporting errors or inaccuracies, or potential management or internal control issues within the firm. The RESTATEMENT variable is assigned a value of 1 if the number of financial restatements in a given year is greater than the median for all firms that year.

Third, we use the number of business segments of the firm (NSEG) as an indicator of organizational complexity, to capture how organizational complexity impacts operational risk. Chernobai et al. (2011) indicated that organizations with higher complexity have higher operational risks, as they are harder to control and monitor. Specifically, when a firm has more business segments, it may make risk management and internal controls more challenging, thus potentially not effectively using increased cash holdings to address these risks. The NSEG variable is assigned a value of 1 if the number of business segments in a given year is greater than the median for all companies.

Fourth, we use the firm's leverage (LEVERAGE) to represent the scale of external financing. Because fluctuations in a firm's cash flow are highly correlated with capital structure (Keefe & Yaghoubi, 2016), higher leverage indicates more total debt and leads to a decrease in cash holdings due to interest expenses. Therefore, we include leverage (LEVERAGE) as a moderating variable to observe how the level of leverage moderates the effect of operational risk on cash holdings. Specifically, we want to know whether,

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when leverage levels are high, the impact of operational risk on cash holdings tends to increase or decrease. The LEVERAGE dummy variable is assigned a value of 1 if the firm's leverage in a given year is greater than the median for all companies.

3.3 Regression Model

This section introduces our empirical strategy for testing the hypotheses H1A and H1B, which concern the relationship between operational risk and corporate cash holdings. The main empirical model, constructed following previous methodologies, is described below:

$$Log(CASH_{i,t}) = \alpha_0 + \alpha_1 OPERATIONAL\ RISK_{i,t} + \alpha_2 MB_{i,t} + \alpha_3 NWC_{i,t} + \alpha_4 LEVERAGE_{i,t} + \alpha_5 CAPEXP_{i,t} + \alpha_6 FIRM\ SIZE_{i,t} + \alpha_7 FIRM\ SIGMA_{i,t} + \varepsilon_{i,t} \quad (1)$$

We follow prior literature by including established determinants of cash holdings decisions as control variables, including those identified in studies by Opler et al. (1999), Dittmar et al. (2003), and Harford et al. (2008). These control variables include the market-to-book ratio (MB), which is measured as the (book value of assets minus book value of equity plus the market value of equity) divided by the book value of assets, to measure the likelihood of the firm having positive net present value projects; net working capital (NWC), which is the ratio of current assets net of cash minus current liabilities divided by assets, reflecting the short-term liquidity position of the firm; the leverage ratio (LEVERAGE), measured as the ratio of total debt (short- and long-term) to assets, indicating the extent of debt financing used by the company; and cash flow from operations (CASHFLOW), measured as earnings after interest, dividends, and taxes, but before depreciation, divided by assets, as stable and predictable cash flows can reduce reliance on cash reserves. Capital expenditures (CAPEXP), measured as the ratio of

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capital expenditures to assets, are included because such expenditures typically involve significant outlays that may affect the firm's cash flow and reserve needs. The natural logarithm of total assets (FIRM SIZE) is used to account for the size of the firm, which may influence its demand for and capacity to hold cash. Cash flow volatility (FIRM SIGMA), a measure of the volatility of the firm's cash flows, is included as higher volatility may necessitate larger cash reserves to cover potential shortfalls. A dividend payment dummy (DIVIDEND PAYER), which takes a value of one if the company pays dividends and zero otherwise, is included to capture the impact of dividend payments on cash management strategies, particularly during periods of financial stress. NWC, CASHFLOW, and CAPEXP are scaled by total assets. Industry and year fixed effects are included to control for industry-specific patterns and the impact of macroeconomic uncertainty over time (Dittmar & Mahrt-Smith, 2007). In equation (1), a positive (negative) α_1 indicates a positive (negative) impact of operational risk on corporate cash holdings. All these variables are defined in Appendix B3.

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4 Empirical Results

In this section, we begin by evaluating the quality and consistency of our data through descriptive statistics, examining data samples, means, quartiles, and standard deviations to understand data distribution and trends. Next, we review the overall scenario of operational risk and cash holdings. Finally, we use a regression model suited to the distribution characteristics of the data, incorporating heterogeneity considerations to analyze the relationship between operational risk and cash holdings.

4.1 Descriptive Statistics

In Panel A of Table 1, we present the changes in operational risk across industries from 2008 to 2023. During this sample period, multiple industries exhibited varying levels of risk changes. Specifically, industries such as Steel, Ships, Mines, Coal, and Tobacco exhibited the highest levels of overall operational risk, often associated with high capital investments and market demand volatility. In contrast, industries like Clothing (Clths), Firearms (Guns), and Rubber (Rubbr) showed significantly lower levels of risk, possibly due to the stability in product demand and lower market volatility. Time-series analysis clearly shows significant volatility in risk values for most industries in specific years, especially from 2019 to 2023, as global economic uncertainty increased—particularly due to the economic impacts of the COVID-19 pandemic—leading to an upward trend in operational risks across many industries. Moreover, the global financial crisis of 2008 and the early stages of the pandemic in 2020 were two apparent peak periods of risk, which greatly affected all sectors.

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Table 1. Distribution of operational risk by industry and year.

Panel A of Table 1 tracks changes in operational risk across various industry sectors from 2008 to 2023, including sectors like Aerospace (Aero), Agriculture (Agric), Automobiles (Autos), Building Materials (BIdMt), and Pharmaceuticals (Drugs). High-risk sectors such as Steel (Steel), Shipping (Ships), Mining (Mines), Coal (Coal), and Tobacco (Smoke) were significantly influenced by substantial capital investments and market demand fluctuations. In contrast, sectors like Clothing (Clths), Firearms (Guns), and Rubber (Rubbr) experienced lower operational risks due to their more stable demand and reduced market volatility. A detailed time-series analysis from 2019 to 2023 highlights increased risk volatility across most sectors, exacerbated by global economic uncertainties, particularly due to the economic impacts of the COVID-19 pandemic. The 2008 global financial crisis and the early stages of the 2020 pandemic were notable for causing sharp increases in operational risks, affecting all sectors extensively.

Panel A: the distribution of operational risk by industry and year

Industry	2008	2009	2010	2011	2012	2013	2014	2015
Aero	0.0290	0.0252	0.0273	0.0272	0.0280	0.0273	0.0241	0.0266
Agric	0.0293	0.0257	0.0282	0.0250	0.0227	0.0254	0.0189	0.0203
Autos	0.0285	0.0292	0.0281	0.0289	0.0289	0.0280	0.0261	0.0251
BIdMt	0.0305	0.0292	0.0286	0.0296	0.0311	0.0312	0.0295	0.0282
Beer	0.0274	0.0237	0.0245	0.0249	0.0250	0.0260	0.0254	0.0285
Books	0.0238	0.0280	0.0261	0.0251	0.0247	0.0237	0.0250	0.0231
Boxes	0.0297	0.0304	0.0290	0.0266	0.0259	0.0264	0.0259	0.0291
BusSv	0.0289	0.0290	0.0267	0.0275	0.0261	0.0255	0.0243	0.0241

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Chems	0.0293	0.0315	0.0310	0.0285	0.0278	0.0272	0.0258	0.0264
Chips	0.0322	0.0313	0.0289	0.0281	0.0273	0.0270	0.0261	0.0263
Clths	0.0240	0.0269	0.0235	0.0252	0.0240	0.0231	0.0229	0.0230
Coal	0.0314	0.0276	0.0304	0.0316	0.0318	0.0314	0.0305	0.0317
Comps	0.0298	0.0302	0.0275	0.0264	0.0256	0.0243	0.0227	0.0238
Construction	0.0342	0.0342	0.0315	0.0297	0.0273	0.0284	0.0262	0.0267
Industry	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Drugs	0.0350	0.0357	0.0328	0.0303	0.0272	0.0280	0.0267	0.0256
ElcEq	0.0268	0.0283	0.0272	0.0293	0.0272	0.0269	0.0286	0.0289
Enrgy	0.0290	0.0300	0.0303	0.0288	0.0279	0.0274	0.0263	0.0264
FabPr	0.0280	0.0340	0.0289	0.0278	0.0261	0.0267	0.0225	0.0254
Food	0.0267	0.0259	0.0251	0.0249	0.0236	0.0244	0.0238	0.0235
Fun	0.0307	0.0276	0.0273	0.0304	0.0295	0.0263	0.0280	0.0260
Gold	0.0278	0.0289	0.0260	0.0233	0.0263	0.0276	0.0256	0.0258
Guns	0.0220	0.0226	0.0235	0.0292	0.0260	0.0244	0.0240	0.0231
Hlth	0.0311	0.0306	0.0298	0.0282	0.0241	0.0245	0.0247	0.0254
Hshld	0.0264	0.0257	0.0269	0.0258	0.0242	0.0232	0.0243	0.0244
LabEq	0.0298	0.0288	0.0268	0.0257	0.0240	0.0257	0.0242	0.0244
Mach	0.0305	0.0294	0.0277	0.0272	0.0281	0.0266	0.0243	0.0251

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Meals	0.0293	0.0300	0.0280	0.0273	0.0257	0.0250	0.0254	0.0263
MedEq	0.0291	0.0294	0.0287	0.0256	0.0240	0.0237	0.0236	0.0223
Mines	0.0300	0.0324	0.0326	0.0320	0.0325	0.0327	0.0308	0.0299
Misc	0.0264	0.0272	0.0265	0.0269	0.0269	0.0250	0.0255	0.0255
Paper	0.0289	0.0309	0.0272	0.0301	0.0274	0.0273	0.0256	0.0265
PerSv	0.0277	0.0265	0.0272	0.0287	0.0287	0.0249	0.0265	0.0262
Rtail	0.0274	0.0274	0.0269	0.0275	0.0265	0.0268	0.0273	0.0268
Rubbr	0.0239	0.0307	0.0265	0.0273	0.0250	0.0250	0.0215	0.0234
Ships	0.0369	0.0324	0.0319	0.0324	0.0360	0.0284	0.0311	0.0290
Smoke	0.0322	0.0370	0.0315	0.0275	0.0251	0.0286	0.0235	0.0279
Soda	0.0248	0.0278	0.0258	0.0253	0.0283	0.0258	0.0240	0.0249
Steel	0.0304	0.0308	0.0318	0.0367	0.0353	0.0329	0.0301	0.0305
TeIcm	0.0300	0.0311	0.0290	0.0274	0.0271	0.0270	0.0269	0.0253
Toys	0.0281	0.0268	0.0268	0.0296	0.0256	0.0242	0.0234	0.0222
Trans	0.0296	0.0296	0.0294	0.0289	0.0275	0.0267	0.0261	0.0277
Txtls	0.0293	0.0307	0.0290	0.0319	0.0289	0.0299	0.0229	0.0262
Unknown	0.0304	0.0334	0.0274	0.0308	0.0286	0.0263	0.0257	0.0247
Whlsl	0.0272	0.0271	0.0253	0.0255	0.0260	0.0259	0.0247	0.0250
Total	1.3020	1.3189	1.2635	1.2647	1.2234	1.1995	1.1476	1.1644

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Panel A: the distribution of operational risk by industry and year

Industry	2016	2017	2018	2019	2020	2021	2022	2023	Total
Aero	0.0257	0.0252	0.0233	0.0247	0.0306	0.0274	0.0254	0.0244	0.4212
Agric	0.0273	0.0316	0.0279	0.0233	0.0254	0.0233	0.0264	0.0241	0.4048
Autos	0.0249	0.0260	0.0235	0.0246	0.0305	0.0278	0.0260	0.0260	0.4322
BIdMt	0.0290	0.0268	0.0254	0.0279	0.0301	0.0282	0.0278	0.0275	0.4606
Beer	0.0294	0.0285	0.0266	0.0263	0.0292	0.0278	0.0265	0.0263	0.4259
Books	0.0236	0.0238	0.0249	0.0230	0.0300	0.0289	0.0282	0.0275	0.4094
Boxes	0.0326	0.0274	0.0276	0.0240	0.0293	0.0270	0.0248	0.0233	0.4393
BusSv	0.0249	0.0239	0.0230	0.0240	0.0274	0.0249	0.0246	0.0250	0.4099
Chems	0.0275	0.0266	0.0269	0.0265	0.0295	0.0272	0.0280	0.0286	0.4482
Chips	0.0274	0.0261	0.0246	0.0251	0.0287	0.0267	0.0266	0.0257	0.4382
Clths	0.0244	0.0232	0.0217	0.0233	0.0282	0.0253	0.0229	0.0238	0.3853
Coal	0.0307	0.0295	0.0257	0.0301	0.0391	0.0288	0.0235	0.0233	0.4771
Comps	0.0242	0.0227	0.0228	0.0219	0.0244	0.0233	0.0223	0.0220	0.3938
Construction	0.0260	0.0248	0.0258	0.0246	0.0310	0.0273	0.0249	0.0256	0.4483
Drugs	0.0251	0.0271	0.0256	0.0261	0.0295	0.0283	0.0278	0.0276	0.4583
ElcEq	0.0292	0.0275	0.0270	0.0249	0.0308	0.0293	0.0290	0.0277	0.4486
Enrgy	0.0264	0.0253	0.0248	0.0254	0.0301	0.0306	0.0284	0.0290	0.4463

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FabPr	0.0245	0.0263	0.0220	0.0255	0.0284	0.0257	0.0244	0.0245	0.4208
Food	0.0240	0.0254	0.0247	0.0241	0.0276	0.0261	0.0248	0.0236	0.3984
Industry	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**Total**
Fun	0.0267	0.0238	0.0215	0.0237	0.0289	0.0256	0.0230	0.0225	0.4214
Gold	0.0267	0.0246	0.0248	0.0255	0.0278	0.0282	0.0292	0.0307	0.4287
Guns	0.0245	0.0239	0.0246	0.0213	0.0267	0.0255	0.0211	0.0222	0.3846
Hlth	0.0234	0.0264	0.0236	0.0233	0.0265	0.0245	0.0229	0.0247	0.4138
Hshld	0.0248	0.0245	0.0230	0.0243	0.0298	0.0269	0.0245	0.0250	0.4037
LabEq	0.0247	0.0238	0.0226	0.0244	0.0279	0.0262	0.0229	0.0235	0.4054
Mach	0.0265	0.0243	0.0231	0.0243	0.0273	0.0258	0.0244	0.0248	0.4194
Meals	0.0251	0.0256	0.0236	0.0244	0.0293	0.0277	0.0244	0.0248	0.4218
MedEq	0.0221	0.0237	0.0217	0.0216	0.0263	0.0255	0.0233	0.0239	0.3947
Mines	0.0299	0.0302	0.0299	0.0282	0.0322	0.0307	0.0299	0.0297	0.4937
Misc	0.0240	0.0212	0.0228	0.0220	0.0268	0.0282	0.0253	0.0268	0.4070
Paper	0.0279	0.0276	0.0254	0.0265	0.0325	0.0283	0.0269	0.0278	0.4468
PerSv	0.0280	0.0272	0.0264	0.0305	0.0320	0.0296	0.0264	0.0261	0.4424
Rtail	0.0265	0.0252	0.0245	0.0256	0.0304	0.0276	0.0270	0.0278	0.4312
Rubbr	0.0233	0.0228	0.0216	0.0216	0.0257	0.0224	0.0235	0.0243	0.3883
Ships	0.0298	0.0299	0.0255	0.0285	0.0306	0.0300	0.0301	0.0311	0.4936

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Smoke	0.0303	0.0297	0.0238	0.0293	0.0325	0.0301	0.0272	0.0260	0.4621
Soda	0.0279	0.0249	0.0227	0.0206	0.0258	0.0260	0.0258	0.0251	0.4053
Steel	0.0312	0.0307	0.0311	0.0303	0.0317	0.0295	0.0290	0.0287	0.5008
TeIcm	0.0264	0.0256	0.0246	0.0250	0.0276	0.0278	0.0260	0.0252	0.4322
Toys	0.0227	0.0242	0.0209	0.0230	0.0241	0.0257	0.0239	0.0250	0.3963
Trans	0.0263	0.0256	0.0253	0.0263	0.0291	0.0266	0.0254	0.0252	0.4351
Txtls	0.0258	0.0283	0.0245	0.0261	0.0272	0.0246	0.0273	0.0245	0.4371
Unknown	0.0255	0.0233	0.0253	0.0272	0.0276	0.0300	0.0263	0.0245	0.4369
Whlsl	0.0234	0.0234	0.0228	0.0255	0.0278	0.0273	0.0253	0.0251	0.4072
Total	1.1872	1.1641	1.1053	1.1299	1.3034	1.2227	1.1608	1.1577	19.3153

Descriptive statistics provided in Table 2 offer an overview of our sample distribution. Our data exhibit a typical financial data characteristic of right-skewed distribution, meaning most data are concentrated at lower values with a few extreme observations. Cash (CASH): The average cash holding in the sample is 0.494, with a median of 0.103, indicating significant variation in cash holdings among firms. 95% of firms hold no more than 1.359, with the lowest 5% nearly at 0.005, showing that most firms maintain relatively low cash reserves. Due to the skewness of this variable, we use the logarithm of cash holdings. Change in Cash (ΔCASH): This variable has an average of 0.086, but the median is near zero, indicating that most samples experience minimal changes in cash, but the average is influenced by some extreme changes. The standard deviation of 3.408 indicates very high volatility in cash changes. Operational Risk (ORISK): The average

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operational risk is 0.027, with a median of 0.025, suggesting that most companies face relatively stable operational risks. The standard deviation of 0.010 shows some variability in risk levels. Market-to-Book Ratio (MB): The average market-to-book ratio is 5.711, with a median of 1.991, indicating that some firms are valued much higher in the market than their book values. The standard deviation of 29.427 shows a very wide distribution of the market-to-book ratio. Firm Size (FIRM SIZE): Represented in logarithmic form, the average firm size is 7.022, with the median close to the average, indicating a relatively balanced size distribution among the sample firms. The standard deviation of 2.083 also shows some variability in firm size.

Table 2. Descriptive Statistics.
This table presents descriptive statistics for the sample in 2008–2023 periods. All variables are as defined in the Appendix B3.

Variables	**N**	**Mean**	**5% quantile**	**Median**	**95% quantile**	**Std. Dev.**
CASH	48684	0.510	0.006	0.109	1.416	3.592
CASH2	48684	1.046	0.007	0.136	3.654	6.792
ΔCASH	48684	0.089	-0.304	0.002	0.548	3.464
ORISK	48684	0.027	0.014	0.025	0.044	0.010
MB	48684	5.893	0.241	2.090	20.819	30.014
CASHFLOW	48684	0.003	-0.278	0.037	0.149	0.180
LEVERAGE	48684	0.279	0.000	0.235	0.711	0.323
CAPEXP	48684	0.028	0.001	0.016	0.099	0.040
FIRM SIZE	48684	6.941	3.540	6.918	10.445	2.056
NWC	48684	0.062	-0.214	0.051	0.422	0.312

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FIRM SIGMA	48684	0.016	0.000	0.007	0.056	0.036
MARKET LEVERAGE	48684	0.235	0.000	0.171	0.719	0.230

Table 3. The determinants of operational risk

This table presents the models including firm, industry, and year fixed effects, with higher explanatory power when these controls are integrated, indicating the significant role of economic and sectoral contexts in understanding operational risks. The robust sample size of 48,684 observations strengthens the reliability of these findings.

Panel A:The determinants of operational risk

ORISK	**(1)**	**(2)**	**(3)**	**(4)**
MB	0.0000198***	0.0000218***	0.0000186***	0.0000205***
	(0.00000542)	(0.00000544)	(0.00000559)	(0.00000560)
NWC	-0.000239	-0.000123	-0.000669***	-0.000526**
	(0.000215)	(0.000212)	(0.000229)	(0.000226)
LEVERAGE	-0.00140***	-0.00123***	-0.00174***	-0.00156***
	(0.000196)	(0.000194)	(0.000206)	(0.000203)
CAPEXP	0.00797***	0.00848***	0.00382**	0.00426***
	(0.00119)	(0.00120)	(0.00149)	(0.00150)
FIRM SIZE	-0.0000441	-0.00000950	-0.000112***	-0.0000734**
	(0.0000286)	(0.0000288)	(0.0000292)	(0.0000294)
DIVIDEND PAYER	0.00324***	0.00338***	0.00314***	0.00328***
	(0.000164)	(0.000163)	(0.000164)	(0.000164)
FIRM SIGMA	0.0133***	0.0123***	0.0123***	0.0112***
	(0.00234)	(0.00231)	(0.00233)	(0.00230)
Year	No	Yes	No	Yes
Industry	No	No	Yes	Yes
N	48684	48684	48684	48684
R^2	0.0163	0.0333	0.0318	0.0487

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4.2 Effect of operational risk on cash holdings

4.2.1 Baseline results

We disclose the outcomes of Equation (1) in Table 4. To ensure robustness, five distinct empirical frameworks are employed to examine the effects of operational risk on cash reserves. These frameworks incorporate various combinations of year and industry effects, along with a streamlined model shown in Column (1). Across all frameworks, the coefficients for ORISK consistently appear positive and statistically significant at the 1%, 5%, or 10% levels, indicating an increase in cash reserves during periods of elevated operational risk. Our empirical results align with Hypothesis 1A rather than Hypothesis 1B, indicating that firms tend to hold more cash. Additionally, our analysis of control variables reveals expected relationships. Notably, the coefficient of Market-to-Book ratio (MB) demonstrates a positive and significant effect, while variables such as net working capital, leverage, cash flow, capital expenditure, and firm size exhibit negative and significant coefficients. This outcome echoes findings from Opler (1999), particularly after accounting for the possibility of firms holding temporary cash reserves.

Specifically, higher levels of net working capital are associated with lower cash holdings, as companies can utilize operational cash flows to meet short-term financial needs, thereby reducing reliance on cash reserves. Moreover, higher leverage ratios correspond to decreased cash holdings, likely due to the elevated interest burden associated with high leverage, prompting firms to allocate cash towards debt repayment. Furthermore, larger firms tend to maintain lower cash balances, potentially attributed to their enhanced market access and greater availability of funding sources, diminishing the necessity for maintaining high levels of cash reserves to mitigate uncertainty.

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Table 4. Operational risk and cash holdings.

This table presents the ordinary least squares regression results of the impact of operational risk on cash holdings. Across all frameworks, the coefficients for ORISK consistently appear positive and statistically significant at the 1%, 5%, or 10% levels, indicating an increase in cash reserves during periods of elevated operational risk. All variables are as defined in the Appendix B3.

Panel A: estimation results

Log(CASH)	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
ORISK	12.10***	9.042***	8.321***	9.399***	9.080***
	(0.767)	(0.672)	(0.677)	(0.604)	(0.629)
MB		0.0293***	0.0282***	0.0207***	0.00911***
		(0.00102)	(0.00102)	(0.000862)	(0.00141)
NWC		-0.940***	-0.934***	-1.079***	-0.929***
		(0.0578)	(0.0573)	(0.0608)	(0.0661)
LEVERAGE		-1.304***	-1.330***	-1.180***	-1.313***
		(0.0582)	(0.0608)	(0.0523)	(0.0573)
CAPEXP		-1.088***	-1.049***	-0.517***	-2.152***
		(0.0780)	(0.0776)	(0.0689)	(0.197)
FIRM SIZE		-0.176***	-0.179***	-0.109***	-0.112***
		(0.00453)	(0.00451)	(0.00385)	(0.00383)
FIRM SIGMA		4.163***	4.022***	2.812***	2.726***
		(0.524)	(0.514)	(0.409)	(0.403)
Year	No	No	Yes	No	Yes
Industry	No	No	No	Yes	Yes
N	48684	48684	48684	48684	48684
R^2	0.00538	0.310	0.318	0.433	0.440

4.2.2 Robustness checks

4.2.2.1 Instrumental variables

Considering the problem of endogeneity, we employ instrumental variable estimation to

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address potential issues of reverse causality. Specifically, we develop an instrument that affects operational risk but does not influence cash holdings. We adopt the approach of Henrique Castro Martins from his paper—Financial materiality and corporate risk: Evidence from an Instrumental Variables (IV) design—using datasets from global non-profit organizations like the "Carbon Disclosure Project" to understand how seriously companies take and are sensitive to risks. In Martins' study, the use of "disclosure of climate and environmental risks" as an instrument led to findings that disclosure of financially material items reduced overall risk. In our study, we use a similar concept and methodology, employing corporate ESG ratings and related data from the Thomson/Refinitiv database to assess companies' performances in sustainability and social responsibility. We hypothesize that companies with better sustainability performance are more sensitive to risks and better able to identify operational risks they are facing or may face in the future, resulting in significant differences in operational risks between companies with high and low scores in sustainability and social responsibility. Additionally, the scores in sustainability and social responsibility do not directly affect their cash holdings, making them suitable for inclusion in our regression strategy as an instrumental variable.

The empirical strategy for the two-stage least squares (2SLS) regression is as follows:

$$OPERATIONAL\ RISK_{i,t} = \gamma\ SCORE_{\ i,t} + \lambda\ X_{i,t} + v_i + w_t + \varepsilon_{i,t}, \quad (3)$$

$$Log(CASH_{i,t}) = \alpha\ \widehat{OPERATIONAL\ RISK}_{\ i,t} + \beta\ X_{i,t} + v_i + w_t + \varepsilon_{i,t}, \quad (4)$$

In the first stage, our goal in estimating equation (3) is to assess the impact of companies' risk disclosure on their level of operational risk. Through regression analysis, we evaluate the impact of climate and environmental risk disclosures on operational risk and test the effectiveness of disclosure policies.

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In the second stage, our goal in estimating equation (4) is to assess the impact of companies' operational risk levels on their cash holdings. Through regression analysis, we evaluate the impact of operational risk on the levels of cash holdings, further understanding the financial structure's response to risk.

We sourced data from the Thomson/Refinitiv database covering the period from 2008 to 2023, totaling 20,320 entries, encompassing the entire regression analysis period. During data processing, we use the company's stock ticker as a key to merge data from two different sources: the ESG scores (SCORE) and the regression sample. In this study, we choose to use the ESG (Environmental, Social, Governance) score as the instrumental variable, covering the dimensions of environmental, social, and governance risks. Companies with high ESG scores are also more likely to proactively identify and address current and future operational risks, thus performing better in sustainability and social responsibility. This makes the ESG score (SCORE) an effective tool for measuring how companies manage these risks to influence their overall operational conditions and thus suitable as an instrumental variable for studying the relationship between operational risk and cash holdings.

Table 5 reveals findings using the instrumental variable approach. Column (1) indicates that the ESG score (SCORE) is a significant predictor of ORISK. Subsequently, we utilize the predicted ORISK (Instrumented-ORISK) to substitute the original ORISK variable in Equation (1). Columns (2) demonstrate that the coefficient for Instrumented-ORISK is negative and statistically significant at the 5% level, suggesting that companies with higher ESG scores may face lower operational risks. These results are consistent with those in Table 4. The relevant test statistics (weak instrument F-statistic) indicate that the

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instrumental variable is appropriate. Typically, an F statistic greater than 10 is considered to indicate that the instrumental variables are unlikely to be weak instruments. This benchmark originates from the research of David Staiger and James H. Stock, who proposed in their 1997 paper that instrumental variable estimates become unreliable when the F statistic is below 10. And our F statistic is 23.41, which is highly above 10.

Table 5. Operational risk and cash holdings: Two-Stage Least Squares (2SLS) Estimation. This table displays the outcomes from the 2SLS regression analysis. In the initial stage of the 2SLS, the ESG score (SCORE) is utilized as the instrumental variable. The F-statistic evaluates the null hypothesis concerning the inadequacy of the instrument, with fixed effects for year and industry included. *, **, and *** indicate statistical significance levels of 10%, 5%, and 1%, respectively. Definitions of all variables are provided in Appendix B3.

	(1) ***ORISK***	(2) ***Log(CASH)***
	1st stage	**2nd stage**
SCORE	-0.001*** (-3.83)	
Instrumented-ORISK		398.540*** (10.89)
Year	Yes	Yes
Industry	Yes	Yes
F-stat	23.41	
N	20,320	20,320
R^2	0.071	0.451

4.2.2.2 Alternative measures of dependent variables

Panel A of Table 6 shows the results for Equation (1) employing different metrics for the cash ratio: Log(CASH2) and change of cash (Δ CASH). The coefficients for control variables in Equation (1) are omitted for conciseness. All columns confirm that the ORISK coefficients are positive and statistically significant at the 1% level, affirming that operational risk positively influences cash holdings.

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Table 6. Robust checks.

This table conducts several robustness tests on the relationship between operational risk and cash reserves. In Panel A, CASH2 is calculated as the ratio of cash assets to net assets, where net assets equal total assets minus cash. Δ CASH represents the change in cash holdings from t-1 to t. Our results indicate that operational risk (ORISK) positively and significantly influences both the ratio of cash to net assets (CASH2) and the annual change in cash holdings (Δ CASH). Specifically, the regression coefficients for ORISK in the Log(CASH2) models are 15.573 and 12.706 (Columns 1 and 2, respectively), both statistically significant at the 1% level with t-values of 22.05 and 19.13. This suggests that higher operational risks lead firms to maintain a higher ratio of cash, likely as a buffer against potential uncertainties. When control variables are included, the effect of ORISK slightly decreases but remains significant, indicating a robust relationship. The R-squared values improve from 0.403 to 0.508 upon including control variables, enhancing the model's explanatory power.

For the Δ CASH models, the coefficients for ORISK are 2.114 and 2.292 (Columns 3 and 4, respectively), also significant at the 1% level with t-values of 4.53 and 4.83, suggesting that companies increase their cash holdings in response to greater operational risks. The introduction of control variables slightly raises the coefficient values, underscoring a clearer impact of operational risk on cash changes even when other factors are considered. Despite the lower R-squared values in these models (0.002 to 0.022), which may reflect the high variability in annual cash changes influenced by numerous factors, the results consistently affirm that operational risk is a critical factor influencing cash retention strategies to cater to future financial pressures or investment opportunities. Definitions of all variables are provided in Appendix B3.

Panel A: alternative measures of cash holdings and subsample regression

	(1)	**(2)**	**(3)**	**(4)**
	Log(CASH2)	**Log(CASH2)**	**Δ CASH**	**Δ CASH**
ORISK	15.573***	12.706***	2.114***	2.292***
	(22.05)	(19.13)	(4.53)	(4.83)
Control variables	No	Yes	No	Yes

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Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
N	48,684	48,684	36,090	36,090
R^2	0.403	0.508	0.002	0.022

4.3 Related results

To further explore the impact of Operational Risk (ORISK) on Cash Holdings (Log(CASH)) and to determine if, as found in Sanz (2023), firms facing operational risks with supplier scarcity hold less cash, we investigated the interaction between operational risk and supplier scarcity (SUPPLIERSCARCITY) on cash holding strategies. Specifically, we analyzed how Operational Risk (ORISK) interacts with Supplier Scarcity (SUPPLIERSCARCITY) to influence firms' cash holding strategies. We introduced the dummy variable Supplier Scarcity (SUPPLIERSCARCITY) to identify firms' supplier scarcity, using a method similar to Hassan et al. (2019) to determine if firms face supply chain-related risks and thus might experience supplier scarcity. According to Sanz (2023), the textual indicators of the supply chain were found to be closely related to supplier scarcity. Texts that mention supply-related terms along with words associated with risk, lack, or similar are considered likely to indicate supplier scarcity. When Supplier Scarcity (SUPPLIERSCARCITY) is 1, it indicates that the firm may face supplier scarcity. The interaction term ORISKSUPPLIERSCARCITY is used to capture how supplier scarcity might alter the impact of operational risk on cash holdings. According to the regression results, we identified three key facts: first, controlling for other factors, operational risk still shows a positive correlation with cash holdings, but the coefficient (10.902) indicates that even in the presence of operational risks, firms may not be able to effectively mitigate these risks by increasing cash reserves, hence the impact of operational risk on cash holdings becomes less pronounced when including supplier scarcity. Second, we confirm that under supplier scarcity, firms indeed hold less cash, with a coefficient of -0.183.

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Third, the significant positive interaction term (ORISKSUPPLIERSCARCITY) indicates that, in the context of high supplier scarcity, the effect of operational risk on cash holdings is more pronounced. It does not explain that operational risk leads to a reduction in cash holdings, thus not supporting Hypothesis H1B.

Table 7. Operational risk and cash holdings: Some related results.

We present some related results from operational risk and cash holdings in Table 7. SUPPLIERSCARCITY is defined as a dummy variable set to one if a company is likely to face the risk of supplier vulnerability; otherwise, it is zero. It does not explain that operational risk leads to a reduction in cash holdings, thus not supporting Hypothesis H1B. Coefficients of control variables are omitted for succinctness. Year and industry fixed effects are accounted for. Parenthesized t-statistics are based on city-clustered standard errors. Asterisks *, **, and *** signify statistical significance at the 10%, 5%, and 1% thresholds, respectively. All variables are as defined in the Appendix B3.

	(1) **Log(CASH)**
ORISK	10.902***
	(10.37)
SUPPLIERSCARCITY	-0.183***
	(-4.58)
ORISK*SUPPLIERSCARCITY	5.938***
	(4.35)
Control Variables	Yes
Year	Yes
Industry	Yes
N	44,751
R^2	0.482

4.4 Other operational risk related factors and cash holdings

In Sections 4.2 "Effect of Operational Risk on Cash Holdings" and 4.3 "Related Results," we obtained robust evidence supporting Hypothesis H1A, showing a positive effect of operational risk on cash holdings. Conversely, H1B was not supported. If the transaction cost and precautionary motives for holding cash prevail, we anticipate that several other operational risk-related factors identified in the literature (e.g., Bhuiyan & Hooks, 2019;

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Chernobai et al., 2011; Doyle et al., 2007; Rashid, 2016) should moderate the relationship between operational risk and cash holdings. We predict that firms with larger board sizes (BSIZE = 1), more financial report restatements (RESTATEMENT = 1), fewer segments (DEFICIT = 0), or smaller market leverage (LEVERAGE = 0) will exhibit a weakened positive impact of operational risk on cash holdings, resulting in less cash held. We employ interaction variables (BSIZE ∗ ORISK, RESTATEMENT ∗ ORISK, DEFICIT ∗ ORISK, LEVERAGE ∗ ORISK) to examine differences in how these operational risk-related factors influence the relationship between operational risk and cash holdings. should moderate the relation between operational risk and cash holdings.

From the regression results in Columns (1), we observe that the interaction term's coefficient is 0.213, statistically significant, indicating that larger board sizes weaken the positive effect of operational risk on cash holdings. The positive coefficient for the interaction term suggests that firms with larger boards have a stronger positive relationship between operational risk and cash holdings, possibly because firms with larger boards may have more problematic directors, which tend to hold more cash. This finding aligns with research on cash holding and over-investment behavior in firms with problem directors (Bhuiyan & Hooks, 2019), which found that firms with larger boards typically have more problematic directors and hence higher cash holdings. Furthermore, some past studies have indicated that fewer board members can reduce agency problems. This analysis confirms the positive association between operational risk and cash holdings and finds this relationship to be influenced by board size, where more directors may lead to reduced decision-making efficiency or increased problems in the decision-making process, thereby increasing the firm's cash needs to manage heightened operational risks.

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From the regression results in Columns (2), the interaction term's coefficient is 274.407, statistically significant, indicating that an increase in financial report restatements amplifies the positive effect of operational risk on cash holdings. This result is consistent with Chernobai et al. (2011), who quantified internal control indicators such as company characteristics, governance metrics, and CEO compensation size and sensitivity, finding significant correlations with internal control events like fraud, misconduct, technical failures, employment discrimination, and execution errors, which are mitigated by improving internal controls and management oversight. Our interaction term result shows that firms experiencing multiple financial restatements exhibit a stronger positive effect of operational risk on cash holdings. A higher number of restatements may indicate more frequent financial reporting errors or inaccuracies, or a lack of management or internal controls, thereby increasing firm risk and intensifying the positive impact on cash holdings.

The number of company segments (NSEG) is represented by the log of the sum of the number of operating and geographic segments reported by the firm in year t. When examining the literature on operational risk and the number of company segments, we find consistent results indicating that firms with significant internal control deficiencies tend to be more complex. Chernobai et al. (2011) suggested that more complex organizations carry higher operational risks due to difficulties in control and monitoring. Similarly, empirical results from Doyle et al. (2007) used the number of company segments as an indicator of organizational complexity, which is higher in firms with significant deficiencies. Thus, we hypothesize that firms facing the same operational risks but with a greater number of segments exacerbate the impact of operational risks, leading to higher cash holdings. However, from the regression results in Columns (3), we observe

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that the interaction term's coefficient is -2.351, statistically significant, suggesting that an increase in the number of company segments weakens the positive effect of operational risk on cash holdings. This indicates that firms with more business segments might actually face higher organizational complexity, making risk management and internal control more challenging, thereby inhibiting the effective use of increased cash holdings to manage these risks.

We hypothesized that when firms have greater than median market leverage (LEVERAGE=1), it should enhance the effect of operational risk on cash holdings because high-leverage firms facing high operational risks are subjected to greater uncertainty and should seek to increase cash holdings. From the regression results in Row (4), we find that the interaction term's coefficient is 2.507, statistically significant, indicating that increased leverage amplifies the positive effect of operational risk on cash holdings. When leverage is high, the impact of operational risk on cash holdings becomes more pronounced. This finding aligns with past literature documenting significant impacts of firm-specific risks on capital structure decisions (e.g., Titman, 1984; Hatzinikolaou et al., 2002). Particularly, Rashid (2016) found that firms with lower firm-specific risks could adjust their leverage to target levels more quickly; conversely, high-risk firms adjusted their leverage more slowly. Therefore, even though firms might choose to increase cash holdings to manage operational risks, the actual change in cash holdings remains influenced by the capital structure.

Table 8. Other operational risk related factors and cash holdings.

This table presents the ordinary least squares regression results of the impact of operational risk on cash holdings. First of all, board size represents the number of directors on the board of a firm at the beginning of the year in our sample period. BSIZE takes a value of one if the firm’s board size is greater than the median value of all firms

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in the same year. Secondly, RESTATEMENT takes a value of one if the firm's number of restatements is greater than the median value of all firms in the same year. Thirdly, NSEG takes a value of one if the firm's log of the sum of the number of operating and geographic segments is greater than the median value of all firms in the same year. Lastly, LEVERAGE takes a value of one if the firm's leverage is greater than the median value of all firms in the same year.

	BSIZE	**RESTATEMENT**	**NSEG**	**LEVERAGE**
Log(CASH)	**(1)**	**(2)**	**(3)**	**(4)**
ORISK	4.518*	9.088***	2.199**	7.920***
	(1.69)	(14.44)	(2.55)	(9.33)
BSIZE	-0.463			
	(-2.67)			
ORISK*BSIZE	14.738**			
	(2.52)			
RESTATEMENT		-6.574***		
		(-16.99)		
ORISK*RESTATEMENT		274.407***		
		(15.20)		
NSEG			0.066**	
			(2.10)	
ORISK*NSEG			-2.351**	
			(-2.14)	
LEVERAGE				-0.862***
				(-23.46)
ORISK*LEVERAGE				2.507**
				(2.04)
Control variables	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
N	3,498	48,684	19,068	48,684
R^2	0.417	0.422	0.081	0.408

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5 Conclusions and future research

This study explores the relationship between operational risk and corporate cash holdings to understand how firms adjust their cash holdings in response to risks. Our baseline results show that firms tend to hold more cash when facing higher operational risks, consistent with our Hypothesis H1A, suggesting a positive correlation between operational risk and cash holdings. This finding aligns with the literature on the precautionary and transaction motives for holding cash (Keynes, 1936). Additionally, our results are robust across different measures of cash holdings and the use of instrumental variable methods, reinforcing our support for Hypothesis H1A, indicating that holding more cash during periods of high operational risk is a strategic choice to mitigate potential financial pressures.

We also observe that when firms face the same operational risks, those with (a) larger board sizes, (b) more financial report restatements, (c) less organizational complexity, or (d) greater leverage tend to hold more cash. These factors that modulate the relationship between cash holdings and operational risks adjust how cash is held in response to these risks.

Consistent with theoretical predictions, we report that firms with greater risks hold more cash during periods of operational risk than those with lower risks. However, cash holdings are also influenced by the capital structure, with high risk and high leverage increasing the need for firms to retain more cash, possibly as a strategy to manage potential financial pressures. Overall, our findings contribute to understanding and verifying the intersections between operational risk, transaction costs, and precautionary motives, as well as the optimal capital structure. Firms' decisions on their cash holding

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strategies are influenced not only by operational risks but also by their leverage or capital structure, which collectively determines how firms balance their needs for risk management and financial burdens.

As with other studies, our literature review has certain limitations. Firstly, this study relies on operational risk management textbooks to establish an operational problem vocabulary. However, the coverage of these textbooks may vary in length and detail on various operational risk topics, potentially omitting relevant terms. The known operational risk-related topics include internal fraud, external fraud, employment practices and workplace safety, clients, products and business practices, damage to physical assets, business disruption and system failures, and execution, delivery, and process management. In the future, collecting high-frequency keywords for each topic might be beneficial to form a more comprehensive operational problem vocabulary. This would allow for a more accurate assessment of the frequency of these terms in earnings call transcripts and a more precise calculation of the level of operational risk.

Secondly, our study investigates the impact of firm-level operational risk on changes in cash holdings and the interaction effect between leverage levels and operational risk on cash holdings. However, we did not provide specific policy and decision-making recommendations to help companies manage their cash holdings more effectively. For instance, the study lacks detailed strategies on how to optimize cash holdings under varying levels of risk and leverage, which may limit the practical applicability of our findings. Future research could combine financial indicators such as profitability and sales to identify the optimal cash holdings for companies under different risk and leverage levels. Additionally, conducting industry-specific analyses by segmenting the sample

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according to industry and analyzing the relationship between operational risk and cash holdings for each industry could provide insights into the specific risks and cash needs faced by different sectors.

Lastly, our study may not have fully considered the influence of economic conditions and market environments on corporate cash holding decisions. Strategies for cash holdings may differ significantly during periods of economic prosperity and recession. The failure to incorporate these external factors might limit the generalizability and applicability of the study's findings. Future research could incorporate macroeconomic variables (such as GDP growth rate, inflation rate, interest rates, and economic sentiment indices) into the model to examine the impact of economic conditions on corporate cash holdings. Alternatively, following Opler et al. (1999), using cross-sectional data from specific years to analyze the impact of particular economic events (such as financial crises or policy changes) on corporate cash holding strategies could be beneficial.

By employing these methods and approaches, future research could more comprehensively consider industry characteristics and external environmental factors, thereby providing more targeted and practically valuable recommendations to assist corporate management in making more informed decisions regarding cash holdings.

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Appendix A1. Detailed definitions of various types of operational risk events

Event-Type Category (Level 1)	Definition
Internal fraud	Losses due to acts of a type intended to defraud, misappropriate property or circumvent regulations, the law or company policy, excluding diversity/ discrimination events, which involves at least one internal party.
External fraud	Losses due to acts of a type intended to defraud, misappropriate property or circumvent the law, by a third party.
Employment Practices and Workplace Safety	Losses arising from acts inconsistent with employment, health or safety laws or agreements, from payment of personal injury claims, or from diversity/discrimination events.
Clients, Products & Business Practices	Losses arising from an unintentional or negligent failure to meet a professional obligation to specific clients (including fiduciary and suitability requirements), or from the nature or design of a product.
Damage to Physical Assets	Losses arising from loss or damage to physical assets from natural disasters or other events.
Business disruption and system failures	Losses arising from disruption of business or system failures.

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Execution, Delivery & Process Management	Losses from failed transaction processing or process management, from relations with trade counterparties and vendors.

Appendix A2. The average number of companies across all years

The average number of companies across all years: 6,090	
Year 2008	3,477 firms
Year 2009	2,875 firms
Year 2010	3,918 firms
Year 2011	5,322 firms
Year 2012	5,035 firms
Year 2013	4,965 firms
Year 2014	4,923 firms
Year 2015	5,139 firms
Year 2016	4,901 firms
Year 2017	5,901 firms
Year 2018	6,954 firms
Year 2019	7,409 firms
Year 2020	8,297 firms
Year 2021	9,135 firms
Year 2022	9,859 firms
Year 2023	9,367 firms

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Appendix A3. Selected Word(s) of Trained Operational Risk List

The table below displays selected words from operational topic-related input, which we utilize for calculating operational risk. The complete list is trained based on raw materials, including several textbooks in operational management.

compliance	outsourcing
control	technology
assessment	infrastructure
business continuity	systematic
recovery	physical
security risks	integrity
breach	network
detection	financial
prevention	credit
safety	liquidity
environment	invest
people	strategy
error	reputation
supply chain	incidental
contingencies	metrics
antitrust	aid
efficiency	improvement
crisis	capacity
operational planning	allocation
datastream	employee
threat	development
secrets	conduct
infringement	stakeholder
property	trade

Appendix A4. Examples of high operational risk

Alexander Jessett - Camden Property Trust, Q2 2020 Earnings Call, Jul 31, 2020

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If you'll recall, for the first 90 days after the COVID storm hit and we went into shutdown mode, we actually, from a policy perspective, just said we're not going to take any renewal increases for the next 60 to 90 days. And then we -- as it turned out, it was a little -- right at 90 days that we just did not process -- we renewed -- offered everybody a renewal at flat. Now could we have -- as it turns out in 20/20 hindsight, could you have gotten 1% or 2% increases? Probably. But from the standpoint of -- 2 thoughts on that. One was we just had no idea how to measure the collapse in demand from 30 million or 40 million jobs evaporating. So there was a great concern on our part that you need to keep every resident that you have in place that it's possible. So that was one part of it.

The second part was really more of a -- it was just more -- in terms of residents who had been kind of shut in to their apartments, most of them working from home. And at the time, we had been mandated in almost every case to close all amenity spaces. So you have people who are in the midst of a pandemic, 40 million job losses, and then they can't even use the amenities. It just seemed like a terrible idea to be pushing through rental increases to our residents at a time where you could -- where they were -- they couldn't even get full value of the proposition that they felt they bargained for.

Achilleas Tasioulas - GasLog Ltd., GasLog Partners LP, Q3 2020 Earnings Call, Nov 10, 2020

While we have taken steps to charter our fleet and maximize their utilization, the outbreak of COVID-19 has dampened demand growth for LNG in 2020, particularly during quarter 2 and quarter 3. In addition, 3 vessels were off-hire for a total of over 100 days related to their scheduled dry-dockings, which were extended due to the challenges with manpower, the yards, a consequence of various lockdown measures in Singapore throughout the year. Looking forward, the partnership has 1 vessel scheduled for dry-docking in the fourth quarter, the Methane Heather Sally, which we anticipate will take 40 days as the vessel is having a ballast water treatment system installed, a regulatory requirement. Slide 34 shows that the partnership's credit profile continues to be resilient with net debt-to-capital at 53%. It is important to note that GasLog Partners has not committed growth CapEx, but we will have one scheduled dry-docking, as I previously mentioned. We expect to continue strengthening the

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balance sheet beginning with the retirement of approximately $19 million of debt over the remainder of this year for a total of $107 million in 2020. Reducing debt balances. We reduced the partnership's cash flow breakeven levels over time, improving the competitiveness of our fleet.

Jack Truong - James Hardie Industries plc, Q2 2021 Earnings Call, Nov 10, 2021

Our Asia Pacific region also had to navigate volatile and uncertain markets during the first quarter, with the first quarter results being significantly impacted by the government-imposed COVID-19 lockdowns in the Philippines and New Zealand. You will remember that on May 5, 2020, we announced the closure of our James Hardie Systems business as well as the closure of our Penrose, New Zealand manufacturing facility. The closure of the James Hardie Systems business is now complete, and we're in the final stages of shutting down our Penrose facility. The shift of production from New Zealand to Australia is driving a better cost per unit outcome for the ANZ region, and exiting of the unprofitable James Hardie Systems business has also had a positive impact on EBIT margins for Asia Pacific.

It is important to note that the Asia Pacific EBIT margin is benefiting from a country mix impact, as the Philippines remained on tighter COVID restrictions during the second quarter compared to Australia and New Zealand. And thus, as a percentage of sales and a percentage of EBIT dollars, the Philippines represented a smaller portion of our Asia Pacific business in the first and second quarters of this year, fiscal year '21, compared to prior periods.

Michael Eliasek - Prospect Capital Corporation, Q3 2020 Earnings Call, Aug 27, 2020

Sure. On the cash front, there's a bit of a one-time factor from the quarter pertaining to assets versus liabilities. Liabilities in the CLO market are generally pegged to 3-month LIBOR while on the asset front, a high percentage, north of 50% of borrowers have elected 1-month LIBOR seeking slightly more advantageous borrowing costs. And as a result, when you have an aggressive move in the Fed, 150 basis points in the month of March, the repricing happened faster to be paid less on assets, while

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liabilities took another quarter to kick in. So that's a one-time factor. That was actually the biggest driver of the cash yield drop that would not reoccur.

On the GAAP yield front, which, as you noted, is a model assumption, basically a calculation of a levelized yield. That's a combination of factors for reduction. Part of it is a drop in LIBOR. So the unlevered or unhedged, if you will, portion does move up and down that portion of the return based on LIBOR and of course, the forward curve moved down pretty significantly in that 90-month -- or 90-day period. There's also an assumption of higher defaults and partial mitigation of higher asset spreads. But the latter has that mitigant, if you will, is not quite as much as one would imagine because collateral managers are derisking. They're also risk-off, using John's excellent parlance. They're going after higher-rated assets to reduce the probability of default, so substituting a higher-rated asset, which on its own, would have a lower spread. So you're not necessarily seeing a huge jump in asset spreads to compensate.

I think the good news is that the pace of both collateral downgrades in the syndicated market as well as tranche downgrades has substantially slowed. There were some pretty dire projections in the earlier part of spring back in the March-April time frame that did not come to fruition. And I've seen at one point a prediction of something like a 12% default rate. That's probably about half now as a consensus prediction. So there'll be -- defaults have become a lagging indicator. There'll be a continued uptick, that's already kind of modeled in. But so far, based on the economic backdrop, it doesn't look it will be nearly as bad as before.

You asked about diversion of cash flows, about 1/4 of deals are experiencing that. And what's easy to forget is the benefits of securitization financing that are substantial and show themselves in times like these. This is not the type of financing where you have a trip of a covenant. And human beings in a conference room far away with dower faces, make proclamations that your expense can accelerate, foreclose, put pressure, what have you. Instead, structured credit and CLOs are self-healing vehicles and the indenture rules the day and cash goes to either purchase new collateral or retire some liabilities, you get back on size the overcollateralization test and cash flow streams get freed up back to the equity after a period of time. We're projecting within 3 months that those diversions will be less than 10% of deals approximately, and we'll reap the benefits from that self-healing process. But what it also shows is the benefits

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of having a diversified book of about 40 deals, and only about 1/4 of those are experiencing diversions that call it akin to a short-term pick on the unlevered loan market equivalent. That's a pretty decent analogy.

Appendix B1. Classification of data types for earnings calls

Event type	Definition	Example
Earnings Calls	Primarily involve publicly listed companies (or potential ones) reporting financials and engaging in discussions with investors and analysts.	Thanks, Patrick. Good morning, everyone, and welcome to our Half Yearly Results Presentation. This is our agenda for today. I'm going to give a short introduction, and then Julia will present a financial review of the first half year.
Company Conference Presentations	Typically conducted at industry conferences or company-hosted events, involving discussions on business operations, development strategies, new products or services, etc.	All right. Well, good morning, everybody. Are you all having a great day? All right. How is the conference going yesterday? Did you enjoy yesterday? Okay. All right, and we're going to have a good event tonight.
Shareholder/Analyst Calls	Targeted towards shareholders and analysts, usually discussing	I think they'll be an absolute amount. We

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	company performance, strategic plans, etc.	haven't defined what it is because we're in a very -- a relatively low investment year, but I think over the autumn, we're going to look at what we think is what I would term a par rate of investment for the group.
Special Calls	Related to specific company events or situations such as major acquisitions, changes in ownership structure, etc.	Thanks, Sander. I'm not going to introduce the break just yet. I do want to conclude by saying that it will take more than 8 months of lockdown interruptions to shift Action of its 2023 plan of EUR 9 billion of sales and EBITDA of over EUR 1 billion.
M&A Calls	Typically associated with mergers and acquisitions, involving discussions on strategic partnerships, merger plans, etc.	Thanks, Dominic. And I couldn't agree more with Dominic's view on the merger. Let me touch upon some of the same points and others on Chart 5. The rationale is clear.

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Analyst/Investor Day	A periodic or ad hoc event where companies invite investors and analysts to a location to present business operations, strategies, future developments, etc.	Good morning ladies and gentlemen and welcome to ABBâs Capital Markets Day, 2011. My name is Johanna Henttonen, Iâm heading ABBâs Investor Relations.Today we have an interesting program around ABBâs strategy 2015 and our financial targets relate.

Appendix B2. The proportions of 48 industry categories

Aero	0.67 %	Chems	2.51 %	Enrgy	5.51 %	LabEq	1.93 %	Rtail	4.97 %	Trans	3.57 %
Agric	0.22 %	Chips	6.25 %	FabPr	0.20 %	Mach	3.05 %	Rubbr	0.41 %	Txtls	0.15 %
Autos	2.07 %	Clths	0.96 %	Food	1.64 %	Meals	1.66 %	Ships	0.24 %	Unknown	0.52 %
BIdMt	1.68 %	Coal	0.26 %	Fun	1.26 %	MedEq	4.04 %	Smoke	0.17 %	Whlsl	2.97 %

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Beer	0.43 %	Comps	2.91 %	Gold	1.40 %	Mines	1.13 %	Soda	0.31 %	Uti	0%
Books	0.41 %	Construction	1.27 %	Guns	0.20 %	Misc	0.78 %	Steel	1.03 %	Banks	0%
Boxes	0.36 %	Drugs	12.16%	Hlth	2.04 %	Paper	0.89 %	TeIcm	3.71 %	Insur	0%
BusSv	16.52%	ElcEq	0.95 %	Hshld	1.39 %	PerSv	1.11 %	Toys	0.47 %	Fin	0%

Appendix B3. Variable definitions

Dependent variables	
CASH	The ratio of cash and cash equivalents to net assets, where net assets is total assets minus cash and cash equivalents.
CASH2	The ratio of cash to net assets, where net assets is total assets minus cash.
Log(CASH)	The natural logarithm of variable CASH.
Log(CASH2)	The natural logarithm of variable CASH.
ΔCASH	The change of CASH from t-1 to t.
Control variables	
MARKET LEVERAGE	Total liabilities divided by total market capitalization reflects the proportion of debt capital to total capital in the company's capital structure.

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MB	market to book ratio of the firm, equals the book value of total assets minus book value of equity plus the market value of equity divided by the book value of total assets.
NWC	Net working capital, calculated as current assets exclusive of CASH (defined above) minus current liabilities divided by total assets.
LEVERAGE	Total liabilities divided by total assets.
CASHFLOW	Operating cash flow divided by total assets.
CAPEXP	Capital expenditures divided by total assets.
GROWTH	Growth rate equals operating income minus lagged operating income scaled by lagged operating income.
FIRM SIZE	The natural logarithm of total assets.
FIRM SIGMA	The standard deviation of the operating cash flow ratio (defined above) in the industry of the year.
DIVIDEND PAYER	DIVIDEND PAYER is an indicator variable takes one if the company pays out dividend in that fiscal year and zero otherwise.
Moderating factors	

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SUPPLIERSCARCITY	Supplier scarcity refers to the condition where a company faces a shortage or limited availability of suppliers for its goods or services.
BSIZE	BSIZE represents the board size, which reflects the number of directors on a company's board.
RESTATEMENT	RESTATEMENT refers to a firm’s number of financial restatements.
NSEG	NSEG stands for number of segments, which serves as an indicator of organizational complexity within a company.
MARKET LEVERAGE	Market leverage refers to the ratio of a company's total debt to its total market equity. It indicates the extent to which a company is financed by debt relative to its equity in the market.
Instrumental variable	
SCORE	Reflects how companies manage risks and perform in sustainability and corporate responsibility.

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